Some Considerations on Solving Linear Systems in Computational Electrodynamics

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The basic equations in electrodynamics are Maxwell's Equations. Something very special about time-dependant electromagnetic fields is the interplay between electric and magnetic field resp. flux. A consistent discretization method should reflect this interrelation which is why Weiland [1] developed the Finite Integration Technique (FIT), some kind of Finite Volume Method on a grid duplet. With FIT, the so-called Maxwell-Grid-Equations (MGE) result: a set of linear equations with operators corresponding one-to-one to the differential operators div, rot and grad. In classical electrodynamics, Poisson's Equation, Helmholtz Equation, etc. are derived from Maxwell's Equations for static or time-harmonic fields, etc.. With FIT corresponding equations can be derived from MGE. Similarly to other methods like FEM, the resulting numerical problems are linear systems of equations or eigenvalue problems, e.g., with large sparse system matrices. The character of the system matrices is depending on the problem class: In the simplest case they are real, symmetric and positive-(semi-)definite; but they can also be complex, non-Hermitian and indefinite. For industrially relevant applications, these systems have a dimension of up to several million unknowns. Solution methods such as Krylov-subspace or multigrid methods allow for efficient numerical field simulation. One important aspect besides convergence speed and storage requirement is a sufficient robustness in order to be applicable for many basically different practical applications. Convergence studies will be presented for a choice of typical examples. Some videos will show the error behaviour and the development of the solution for real life applications.

References

[1] T. WEILAND: Eine Methode zur Lösung der Maxwellschen Gleichungen für sechskomponentige Felder auf diskreter Basis, AEÜ, **31** (1977), 116–120.

[2] U. VAN RIENEN; M. CLEMENS; T. WEILAND: Computation of Low-Frequency Electromagnetic Fields. ZAMM, **76** (1996), Suppl. 1, 567–568.

[3] M. CLEMENS; R. SCHUHMANN; U. VAN RIENEN; T. WEILAND: Modern Krylov Subspace Methods for the Computation of Electro-Quasistatic Fields and Time-Harmonic Fields with Open Waveguide Boundaries.

ACES Journal Special Issue on Applied Mathematics: "Meeting the Challenges Presented by Computational Electromagnetics", **11** (1996), No. 1, 70–84.

[4] M. Clemens; P. Thoma; T. Weiland; U. van Rienen: A Survey on the Computational Electromagnetic Field Calculation with the FI-Method. Surveys on Mathematics for Industry, **8** (1999), No. 3-4, 213–232.

[5] G. Pöplau, U. van Rienen: Multigrid Algorithms for the Tracking of Electron Beams, presented at the 6th European Multigrid Conference EMG'99, September 27-30, 1999, Universiteit Gent, Belgium.

[6] U. Schreiber, U. van Rienen: Simulation of the Behavior of Droplets on Polymeric Surfaces under the Influence of an Applied Electrical Field, presented at the 9th Biennial IEEE Conference, CEFC 2000, June 4–7, 2000, Milwaukee, USA.